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GAS TURBINE AND JET ENGINE FUELS

PROGRESS REPORT NO. 6

NAVY CONTRACT, NOas 60-6009-C

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Progress Report No. 6

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GAS TURBINE AND JET ENGINE FUELS

by

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SUMMARY

The sixth bimonthly period under Navy Contract NOas 60-6009-c has been spent in a brief study of the effect on two-inch combustor flame tube durability of the addition of two phosphorus—containing corrosion inhibitors and tri-cresyl-phosphate to a synthetic 1.0 per cent sulfur base fuel. The corrosion inhibitors used were two commercial additives approved for use in military jet fuels. Tri-cresyl-phosphate was included to provide a phosphorus compound of known species.

This effort was made to check possibilities of accelerated rates of sulfur corrosion of turbine "hot section" components when phosphorus containing corrosion inhibitors were added to high sulfur jet fuels. The results failed to confirm this insofar as 304 stainless steel flame tubes are concerned. Instead, these tests showed no accelerated deterioration of flame tubes by any of these three materials, with some slight indication of a reduction in flame tube metal loss as a result of the addition of the two commercial inhibitors included in the study.

Research Division Report 2750-60R

PHILLIPS PETROLEUM COMPANY

BARTLESVILLE, OKLAHOMA

Progress Report No. 6

NAVY CONTRACT NOas 60-6009-c

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I. INTRODUCTION

The sixth bimonthly period under Navy Contract NOas 60-6009-c has been spent continuing the study of the effects of jet fuel sulfur on combustor durability. During this period an effort has been made to follow up reports indicating an acceleration in the rate of sulfur corrosion of turbine "hot section" components when phosphorus containing corrosion inhibitors were added to high sulfur jet fuels. For this work two commercial phosphorus-containing corrosion inhibitors, which are included in those approved for use in military jet fuels, were blended into an alkylate base fuel which was previously treated with 1.0 per cent sulfur as ditertiary butyl disulfide. A third phosphorus compound of known species, tri-cresyl-phosphate, was also included in this work. In order to accelerate flame tube metal losses, for test purposes, the sulfur level was held at 2 1/2 times the maximum allowed by military jet fuel specifications and the phosphorus level was 2 1/2 times the phosphorus concentration which would result from maximum treatment as recommended by the manufacturer of Additive A.

II. TEST PROGRAM

The test program and apparatus utilized in these investigations has been previously described in detail in (1). Briefly, the current tests involve running combustor flame tube metal loss tests in the Phillips 2-Inch Research Combustor using a low sulfur alkylate base fuel into which 1.0 per cent sulfur in the form of ditertiary butyl disulfide had been blended. Phosphorus inhibitor Additives "A" and "B" and tri-cresyl-phosphate were then added to a concentration of 9 ppm of phosphorus. These concentrations of sulfur and phosphorus are approximately 2 1/2 times those to be expected in a finished jet fuel. The use of ditertiary butyl disulfide was justified on the basis of previous work, (1), (2), which had shown little or no difference between sulfur compounds with regard to their effect on flame tube metal loss, and because of extensive data already available with this compound at the 1.0 per cent sulfur level.

Combustor test conditions were the same as employed in the previous jet fuel sulfur work reported in (1) and (2); combustor pressure was held at 350 in. Hg abs., inlet air temperature at 700 F, inlet reference velocity at 100 fps and fuel-air ratio at 0.010 lb. fuel per lb. of air. All tests were run using type 304 stainless steel flame tubes of the revised design mentioned in (2).

III. DISCUSSION OF RESULTS

The results of this series of tests are tabulated in Table I and plotted in Figure 1. It is readily apparent from the plots of Figure 1 that none of the phosphorus containing compounds were deleterious with regard to flame tube durability. Tri-cresyl-phosphate appeared inert in that the curve for this compound lies within the repeatability band established for the base fuel plus 1.0 per cent sulfur as ditertiary butyl disulfide. Additives "A" and "B" did show some slight tendency to reduce metal losses and their performances were nearly identical. However, because of the rather broad repeatability band known to exist for this test method it is considered possible that the apparent reduction in metal loss observed for Additives "A" and "B" may not be significant. In any case, it appears from this work that these phosphorus compounds caused no deleterious effects on 304 stainless steel flame tubes.

IV. CONCLUSIONS

Flame tube metal loss tests carried out to investigate the effect of the addition of phosphorus containing jet fuel corrosion inhibitors to a synthetic 1.0 per cent sulfur base fuel have shown that these compounds did not contribute to or accelerate the loss of metal from flame tubes beyond the level normally expected for the base fuel. Some light indication of a reduction in metal loss was observed for two of the materials tested, both of which are corrosion inhibitors approved for use in military jet fuels.

V. REFERENCES

1. Streets, W. L.; "Gas Turbine and Jet Engine Fuels", Progress Report No. 2, Navy Contract NOas 60-6009-c, Phillips Research Division Report 2572-60R, February, 1960.

2. Streets, W. L.; "Gas Turbine and Jet Engine Fuels", Progress Report No. 5, Navy Contract NOas-60-6009-c, Phillips Research Division Report 2690-60R, August, 1960.

TABLE I

EFFECT OF PHOSPHORUS CORROSION INHIBITORS ON SULFUR CORROSION OF PHILLIPS 2-INCH RESEARCH COMBUSTOR FLAME TUBES

Combustor Operating Conditions: P = 350 in. Hg abs.; V = 100 f.p.s; IAT = 700 F; F/A = 0.010
Flame Tube Metal Type: 304 S. S.

Test Fuel Blend	Test Time, Hrs.	Flame Tube Metal Loss, g.
Alkylate Base Fuel (B845) + 1% (wt.) Sulfur as Ditertiary Butyl Disulfide	1	6.7, 6.8, 7.8, 7.9
	2	21.3, 24.8, 26.3, 24.2
	3	41.2, 43.6, 52.2, 41.6
Alkylate Base Fuel (B889) + 1% (wt.) Sulfur as Ditertiary Butyl Disulfide + 0.0009% (wt.) Phosphorus as Additive "A"	1	5.4
	2	18.1
	3	36.4
Alkylate Base Fuel (B889) + 1% (wt.) Sulfur as Ditertiary Butyl Disulfide + 0.0009% (wt.) Phosphorus as Additive "B"	1	5.0
	2	18.5
	3	37.5
Alkylate Base Fuel (B889) + 1% (wt.) Sulfur as Ditertiary Butyl Disulfide + 0.0009% (wt.) Phosphorus as Tri-cresyl-phosphate	1	6.6
	2	22.1
	3	42.9

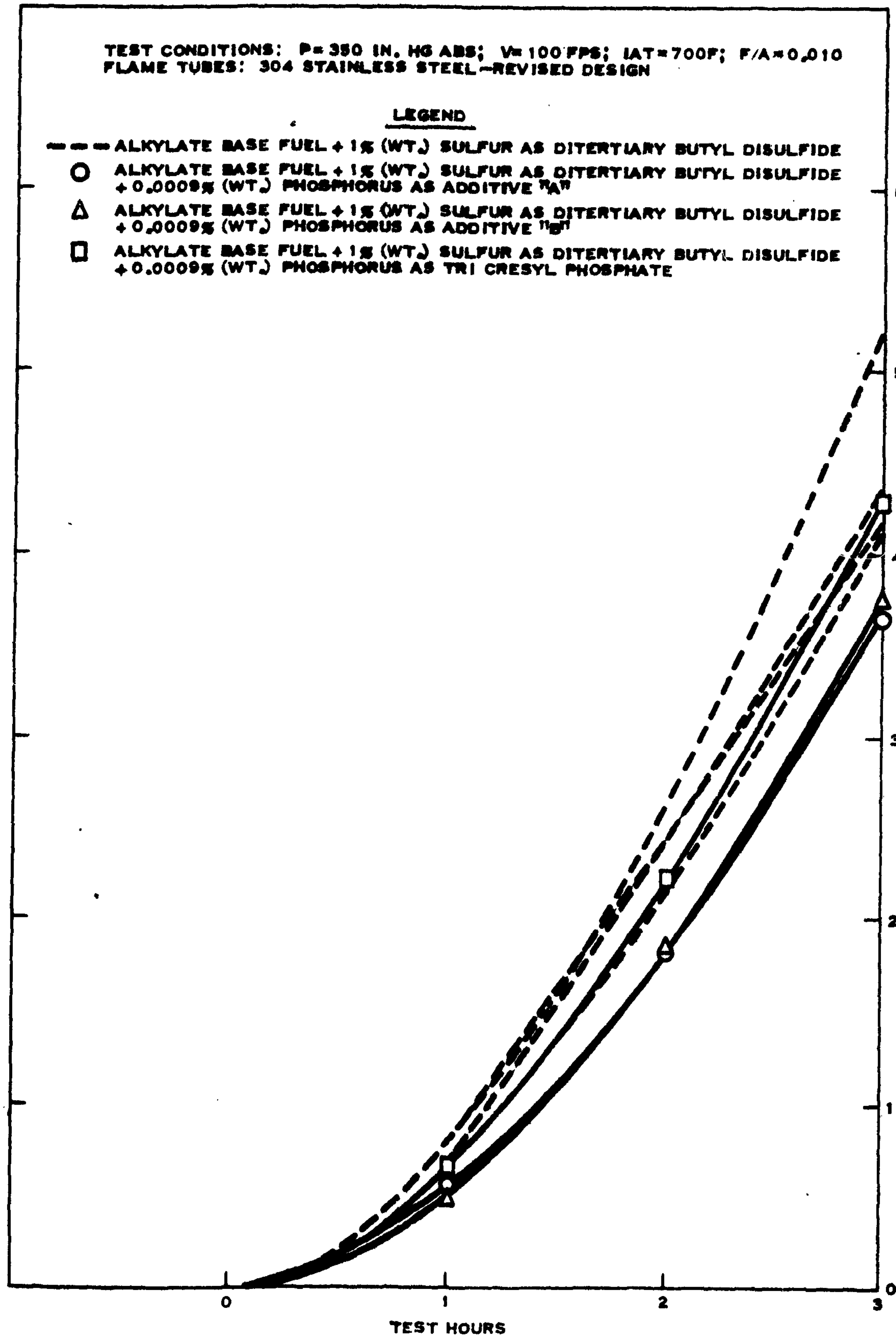

FIGURE 1
FLAME TUBE METAL LOSS AS A FUNCTION OF COMBUSTOR TEST TIME FOR A SYNTHETIC HIGH-SULFUR FUEL PLUS PHOSPHORUS-CONTAINING FUEL ADDITIVES.